418 Rec'd PCT/PTO 18 FEB 2000

FORM PTO-1390 (REV 10-94) — U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371

ATTORNEY'S DOCKET NUMBER: RCA 88741	U.S. APPLICATION NO (If known, see 37 CFR 1.5): 09/485940	
INTERNATIONAL APPLICATION NO: PCT/US98/17920	INTERNATIONAL FILING DATE: 28August1998(28.08.98)	PRIORITY DATE CLAIMED: 29August1997(29.08.97)

TITLE OF INVENTION: DIGITAL RASTER CORRECTION

APPLICANT(S) FOR DO/EO/US: John Barrett George and Frank Albert Glad

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. ☒ This express request to begin national examination procedures (35 U.S.C. 371(f)) at any time rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and PCT Articles 22 and 39(1)
4. ☒ A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date
5. ☒ A copy of the International Application as filed (35 U.S.C. 371(c)(2))
   a. ☐ is transmitted herewith (required only if not transmitted by the International Bureau).
   b. ☒ has been transmitted by the International Bureau.
   c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US)
6. ☐ A translation of the International Application into English (35 U.S.C. 371(c)(2)).
7. ☒ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))
   a. ☐ are transmitted herewith (required only if not transmitted by the International Bureau).
   b. ☐ have been transmitted by the International Bureau.
   c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
   d. ☒ have not been made and will not be made.
8. ☐ A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
9. ☒ An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).
10. ☐ A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11. to 16. below concern document(s) or information included:

11. ☒ An Information Disclosure Statement under 37 CFR 1.97 and 1.98. with references attached
12. ☒ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included
13. ☒ A FIRST preliminary amendment.
    ☐ A SECOND or SUBSEQUENT preliminary amendment.
14. ☐ A substitute specification.
15. ☐ A change of power of attorney and/or address letter.
16. ☒ Other items or information: Copy of PCT Notification of the Recording of a Change (PCT/IB/306)

CERTIFICATE OF MAILING UNDER 37 CFR 1.10

EL533648998US — "Express Mail" mailing no.

18 February 2000 — Date of Deposit

I hereby certify that this application is being deposited with the United States Postal Service "Express Mail Post Office to Addressee" service under 37 CFR 1.10 on the date indicated above and is addressed to the Assistant Commissioner for Patents, Washington, D.C. 20231.

Davida Fornarotto — Typed or printed name of person mailing application

Davida Fornarotto — Signature of person mailing application

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(January 1994)

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U.S. APPLICATION NO. (if known, see 37 CFR 1.5)	INTERNATIONAL APPLICATION NO	ATTORNEY'S DOCKET NUMBER
09/485940	PCT/US98/17920	RCA 88741

17 [X] The following fees are submitted:

	CALCULATIONS	PTO USE ONLY
BASIC NATIONAL FEE (37 CFR 1.492(a)(1)-(5)):		
Search Report has been prepared by the EPO or JPO. .. $840.00		
International preliminary examination fee paid to USPTO (37 CFR 1.482) $670.00		
No international preliminary examination fee paid to USPTO (37 CFR 1.482) but international search fee paid to USPTO (37 CFR 1.445(a)(2)).. $760.00		
Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO......... $970.00		
International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(2)-(4)............ $96.00		
ENTER APPROPRIATE BASIC FEE AMOUNT =	$ 970.00	
Surcharge of **$130.00** for furnishing the oath or declaration later than [ ] 20 [ ] 30 months from the earliest claimed priority date (37 CFR 1.492(e)).	$	

CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE		
Total claims	7 -20 =	0	X 18.00	$	
Independent claims	2 -3 =	0	X 78.00	$	
MULTIPLE DEPENDENT CLAIM(S) (if applicable)			+ 260.00	$	

TOTAL OF ABOVE CALCULATIONS =	$ 970.00	
Reduction by 1/2 for filing by small entity, if applicable. Verified Small Entity Statement must also be filed (Note 37 CFR 1.9, 1.27, 1.28).	$	
SUBTOTAL =	$ 970.00	
Processing fee of **$130.00** for furnishing the English translation later than [ ] 20 [ ] 30 months from the earliest claimed priority date (37 CFR 1.492(f)). +	$	
TOTAL NATIONAL FEE =	$ 970.00	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). **$40.00** per property +	$ 40.00	
TOTAL FEES ENCLOSED =	$ 1010.00	
	Amount to be: refunded	$
	charged	$ 1010.00

a. [ ] A check in the amount of $__________ to cover the above fees is enclosed.

b. [X] Please charge my Deposit Account No. 07-0832 in the amount of $ 1010.00 to cover the above fees. A duplicate copy of this sheet is enclosed.

c. [X] The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 07-0832. A duplicate copy of this sheet is enclosed.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO

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SIGNATURE

Francis A. Davenport

NAME

36,316

REGISTRATION NUMBER

00 FEB 22 AM 10: 56

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant : John Barrett George and Frank Albert Glad

Filed : Herewith

For : DIGITAL RASTER CORRECTION

PRELIMINARY AMENDMENT

Hon. Assistant Commissioner for Patents
Washington, D.C. 20231

Sir:

In the US national phase application of PCT/US98/17920 filed herewith, please enter the following amendments

IN THE CLAIMS:

Please amend the claims (which are the claims as per the International Preliminary Examination Report) as follows:

5. (AMENDED) A video display apparatus, comprising:

a cathode ray tube [(10)] for displaying an image, having a deflection correction coil [(GVC)] mounted thereon and coupled to drive amplifier [(107)];.

a digital to analog converter [(105)] with an output coupled to said drive amplifier [(107)];

a memory [(104)] containing displacement values applicable to spaced points in a grid of rows [(1-13)] and columns [(A-P)], said displacement values for said columns [(A-P)] generally defining S-shaped correction curves having a maximum value at two areas of a display screen located substantially between a center axis [(7)] and ones of top and bottom edges [(2,13)] of the display, said S-shaped correction curves having substantially zero value at areas adjacent to said center axis [(7)] and said edges [(2,13)]; and,

interpolating means [(102)] for interpolating intervening values adjacent ones of said displacement values and having an output coupled to said digital to analog converter [(105)] for generating a corrective signal [(I2corG)] to drive said deflection correction coil [(GVC)] for locally adjusting a position of said image such that banding and pincushion distortion are controlled.

6. (AMENDED) The video display of claim 5, wherein S-shaped correction is added in successive steps proceeding from said areas located substantially between said center axis [(7)] and said ones of top and bottom edges [(2,13)], toward said center axis [(7)] and toward said edges [(2,13)], respectively.

7. (AMENDED) The video display of claim 5, wherein said digital words stored in said memory [(104)] represent values derived during alignment of said video display.

8. (AMENDED) The video display of claim 5, wherein said digital words defining displacement values stored in said memory represent values formed by interpolation of displacement values applicable to said grid.

10 (AMENDED) The video display of claim 5, wherein said linear interpolating means generates said intervening values adjacent ones of said displacement values during a display period.

12.(AMENDED) A method for digitally correcting geometric distortion of an image on a display screen, comprising the steps of:

defining a matrix of spaced adjustment points [(A1-P13)] on the display screen, in horizontally spaced vertical columns [(A-P)] of values for local displacement of the image at the adjustment points on the display screen, the values for said columns defining S-shaped vertical correction waveforms having varying slope between adjacent ones of the values;

linearizing the values for at least two areas of the matrix corresponding to a center axis [(7)] and top and bottom edges [(2,13)], and applying progressively greater S-correction proceeding from said center axis and from said edges, to areas of the display screen located substantially between said center axis [(7)] and said edges [(2,13)];

storing the matrix values in a memory [(104)];

reading said stored matrix values; and,

locally displacing said image as a function of said stored matrix values for corresponding adjustment points to correct the image on the display screen such that banding and pincushion distortion are controlled.

13. (AMENDED) The method of claim 12, further comprising linearly interpolating between adjacent ones of the matrix values in said vertical columns [(A-P)] to define correction values for scan lines between the adjustment points, and locally displacing the image between the adjustment points as a function of the linearly interpolated correction values.

IN THE ABSTRACT

Please add the attached Abstract.

REMARKS

The above amendments to the have been made to eliminate reference indicia. No new matter has been added.

To meet the requirements of the United States, the Abstract (as originally filed in the PCT application) is added.

No fee is believed to have been incurred by virtue of this amendment. However if a fee is incurred on the basis of this amendment, please charge such fee against deposit account 07-0832

Respectfully submitted,
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February 18, 2000

8 pts

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DIGITAL RASTER CORRECTION

This disclosure relates to the field of deflection correction waveform generation and in particular to the digital generation of geometric and convergence correction signal waveforms.

BACKGROUND OF THE INVENTION

Digital convergence in a projection television receiver can be achieved using a two dimensional matrix of adjustable factors applicable to points distributed at regular intervals across the visible screen area. The degree of deflection correction may be finely adjusted at each of these points independently.

In the horizontal direction the deflection correction is determined by a numeric digital factor applicable at the matrix points, which is converted to an analog signal for driving a convergence correction coil. At intermediate points between the points on the matrix, the correction factor is determined by averaging with an analog filter. In the vertical direction it is necessary to calculate the values for the intervening scan lines between the lines corresponding to the points on the correction matrix. In a lower cost display system, correction for the lines between the points that are numerically defined are determined by taking a difference between the correction values for the nearest adjustment point above and below the point in question, dividing by the number of lines in between the adjustment points, and weighting the correction value for the particular line being determined by linear interpolation. Thus the waveform that is generated follows a straight line between the two numeric points. To facilitate interlace scanning an offset value may be added to the correction data for alternate fields.

Digital correction may affect picture geometry in addition to converging corresponding points on the three color rasters. Green is typically chosen to be centered on the projection system optical axis. In this position, the image on the face of the green tube suffers least geometric distortion. Red and blue displays are positioned on the axis vertically but typically are located off the optical axis horizontally. As a result, the red and blue rasters are additionally distorted and require keystone shaping to compensate for this off axis projection

location. Because the optical distortion is minimum for the green image, it is chosen as the geometric reference. The green raster is sized and shaped by correction waveforms to minimize geometric distortion. The red and blue rasters are then matched to align precisely with the green image.

The uncorrected green raster suffers a large vertical pincushion distortion which is corrected by a correction waveform. For optimum geometry, the correction waveform along each column has a distinct S-shape having sinusoidal and parabolic components, and for the off axis red and blue images an additional linear component is required.

The correction waveform may, for example, be adjustable along a matrix of factors defining 13 rows and 16 columns. For each point in the matrix, numerical factors define the associated displacement of the red, green and blue rasters to be effected at that point for achieving accurate picture geometry and alignment of the red and blue rasters. Since the number of correction points or nodes for each column is relatively small, for example twelve points spaced vertically in the visible area of the screen, the linearly interpolated S-shaped correction waveform may have abrupt changes in slope as it crosses each node. These slope changes at each adjustment line cause blocks of raster scan lines to appear with a brightness difference due to non-uniform spacing of the horizontal lines in adjacent areas where convergence is adjusted according to different matrix factors. If a video signal having a constant level or a "flat" field is displayed, the raster will exhibit a series of distinct horizontal bands or lines of differing brightness resulting from correction waveform discontinuities.

SUMMARY OF THE INVENTION:

In an inventive arrangement a circuit generates a correction signal to correct image distortion on a display screen. A memory stores displacement values corresponding to spaced points on the screen in a grid of rows and columns. The displacement values of the grid generally defining correction curves for correcting the image distortion without introducing significant banded regions on the

display screen. An interpolator is coupled to the memory for interpolating intermediate values between adjacent ones of the stored displacement values. A digital to analog converter is coupled to the interpolator for providing the correction signal.

In a further inventive arrangement a video apparatus has a cathode ray tube displays an image subject to image distortion. A deflection coil is located on the cathode ray tube and is driven by a drive amplifier. A digital to analog converter generates an output signal which is coupled to the drive amplifier. A memory has stored interpolated displacement values corresponding to spaced points on the in a grid of rows and columns. An interpolator is coupled to the memory and responsive to the stored interpolated displacement values the interpolator interpolates values adjacent to ones of the stored interpolated displacement values. The digital to analog converter is coupled to the interpolator and generates a correction signal to drive the deflection coil to correct the image distortion.

IN THE DRAWINGS:

FIGURE 1 is a block diagram showing the elements of a digital correction circuit.

FIGURE 2 is a block diagram illustrating a projection display having digital raster correction means.

FIGURE 3 illustrates a nominal raster pattern with ideal geometry, the visible portion being cross hatched and a matrix of adjustment points being shown as circles or dots.

FIGURE 4 shows a portion of the pattern of FIGURE 3 with interpolated points between the adjustment points shown as crosses or X's.

FIGURE 5 is a plot of ideal geometry convergence correction waveforms for the columns of a center axis raster (e.g., the green raster of a projection television), except having straight lines connecting the adjustment points as characteristic of linear interpolation.

FIGURE 6 depicts a flat field video raster with brightness banding resulting from abrupt slope changes in a column correction waveform due to linear interpolation between discrete matrix

adjustment points depicted in FIGURE 5.

FIGURE 7 is a plot of linear rather than S-shaped correction waveforms for eliminating banding as in FIGURE 6.

FIGURE 8 shows inner pincushion distortion produced by linear column correction as depicted in FIGURE 7.

FIGURE 9 is a plot of column corrections according to an inventive aspect.

FIGURE 10 is a chart of equations for determining column values according to an inventive aspect and as shown in FIGURE 9.

FIGURES 11A and 11B are five by five adjustment matrices illustrating simplified linearizing value interpolation and of S-correction of selected linearized matrix column values.

FIGURE 12 is a simplified flow chart illustrating an advantageous addition of S-curvature to a linearized 13 by 16 correction matrix.

DETAILED DESCRIPTION:

A digital raster correction system generally consists of a pattern generator, an amplifier for driving the convergence yokes, a memory for storing correction constants, and an interface to a controller or microprocessor. Such a system is shown with a single cathode ray tube and deflection arrangement in FIGURE 1.

The digital raster correction system includes an internal controller 102. A microprocessor 30A may be employed together with an external video circuit 20 coupled to a convergence pattern generator 120 for independent adjustments and viewing of geometric or convergence correction. An external setup microprocessor, shown with a dotted outline, is used to process initial adjustment values which are written to EEPROM 103. Such an external microprocessor driven adjustment may be accomplished using automatic means to record and analyze convergence test pattern displays, and for generating initial or updated correction factors. Adjustments to geometric or convergence correction may be required, for example, to correct for mis-convergence resulting from changes in display orientation relative to the Earth's magnetic field or as a result of component failure, and these changes to the correction values stored EEPROM 103 may be accomplished by microprocessor 30A.

FIGURE 1 illustrates some digital portions and FIGURE 2 illustrates the drive circuits and CRTs of an exemplary projection display system with which the digital raster correction method and apparatus of the invention may be advantageously employed. Digital correction circuit 100 in FIGURE 1 includes EEPROM 103, which provides nonvolatile storage of correction or adjustment factors, internal RAM 104 for volatile storage, and a digital to analog converter DAC 105, each coupled to controller 102.

Geometric or convergence adjustments are made by defining a matrix of adjustment points for each of the three colors. The on-screen video pattern generator 120 can provide location references for adjustments at particular locations on the display corresponding to the matrix of data points stored in EEPROM 103. Adjustment or correction data from EEPROM 103 can be read into internal RAM 104 at power-up, and then used to generate further factors such as interpolated factors for use between adjacent reference locations. Internal RAM 104 stores 1248 data words which represent a matrix of 13 by 16 points, with X alignment points horizontally by Y alignment points vertically, by 2 representing horizontal and vertical corrections, by 3 representing the three display devices forming R, G and B images.

The active scan area of a display means, for example, is divided into a matrix of rows and columns, for the purposes of corrective control. The boundary lines of the rows and columns can be considered to define a cross hatch grid. FIGURE 3 shows an exemplary display screen illustrating such a cross hatch grid in which the active or visible area is defined by a shaded rectangle. For purposes of illustration, the number of vertical grid points or samples is 13, and the number of horizontal samples is 16. These numbers are chosen merely for example. The number of rows and columns, and the resulting sections, are selected depending on the desired extent of correction in the resulting raster.

Positive or negative horizontal and vertical corrections may be employed for each of the three colors at each measurement point, as well as on the intervening horizontal scan lines between the

measurement points. Referring to FIGURE 1, the signals are read out by controller 102 and coupled to digital to analog converter 105, the output of which is smoothed by low pass filter 106 and amplified by drive amplifier 107. The filter output is a current signal representing the current necessary in correction coil 108 to correctly converge, or minimize geometric distortion of the raster generated on CRT 10. Amplifier 107 may be a feedback amplifier that measures instantaneous coil current and matches the current in correction coil 108 as a function of the output of digital to analog converter (DAC) 105 as the adjustment factors are read out during raster scanning. The correction current flow through coil 108 results in the raster scanned image formed by on CRT 10 appearing with convergence correction or minimized geometric distortion.

In FIGURE 4, the six circled points $C2_0$ through $E4_0$ represent a subset of point locations for which correction data is defined. The correction values at grid points marked X, $C2_1$ through $C2_4$, for example, namely the values used between $C2_0$ and $C3_0$, are calculated by interpolation between the values of $C2_0$ and $C3_0$. As a result, if the correction values are plotted for the columns, they are categorized by linear straight lines between the circles, with discontinuities, or abrupt changes of slope, occurring at the circled points.

In FIGURE 2, separate red, green and blue amplifiers 110, 210, 310 correspond to amplifier 107 in the more general diagram of FIGURE 1. Amplifiers 110, 210, 310 drive correction coils RVC, GVC, BVC with signals provided by digital convergence generator 30, shown generally in FIGURE 2. Corresponding amplifiers (not shown) are provided for horizontal correction coils RHC, GHC, BHC. The signals driving correction amplifiers 110, 210, 310 and their respective coils are read out synchronously with the horizontal and vertical rates as provided by a sync separator 20. The horizontal and vertical rates are also coupled to a bus controlled waveform generator 21 which generates horizontal and vertical waveforms. The vertical sawtooth signal is adjusted within generator 21 to provide pincushion, trapezoidal and S correction and this shaped, or pre-distorted

waveform is coupled to a vertical deflection amplifier 80 and deflection yokes GV, RV, BV of three CRTs. In FIGURE 2. the vertical deflection generator and amplifier 80 is depicted with a dotted box to indicate that vertical waveform generation and shaping occurs within waveform generator 21.

FIGURE 3 may be considered to represent a green reference crosshatch pattern with perfect geometry, as might be achieved by the correction curves shown in FIGURE 5. The Y axis of FIGURE 5 shows the numeric correction values that drive the vertical green digital-to-analog converter and represent correction current amplitude in correction coil GVC. Each of the sixteen curves is a line plot wherein the discrete values at spaced adjacent points along each of the 16 vertical columns of the cross hatch are connected by lines. Series C_0-O_0 are the columns that are visible on the screen. Series A, B and P occur during horizontal retrace and may be used for fine adjustment of the vertical position of the ends of the cross hatch horizontal lines.

Whereas there are more horizontal lines in the display than vertical points in a matrix of the convergence correction factors as suggested by FIGURE 4. In order to proceed smoothly from one matrix value to the next, controller 102 linearly interpolates the value for each successive vertically spaced horizontal scan line. Referring to FIGURE 4, the correction at the intermediate "X" lines between matrix points $C2_0$ and $C3_0$ progresses linearly in equal increments. Subpoint $C2_1 = C2_0 + (C3_0 - C2_0)/5$, and subpoint $C2_2 = C2_0 + 2*(C3_0 - C2_0)/5$, etc. The correction values for the circled matrix points are stored in EEPROM 103 and read out at startup of the display. The values for the intermediate or "X" points may be calculated upon startup and stored in RAM 104, or calculated “on the fly” during each display period from the stored circled matrix point values using an interpolation integrated circuit such as the SGS Thomson STV4020 Digital Convergence IC. Alternatively, the incremental difference (e.g., (C3-C2)/5) may be calculated at startup and stored, and added incrementally to $C2_0$ or the preceding convergence correction factor used.

Linear interpolation is relatively simple but produces

sharp inflection points where the slope of the nominally S-shaped correction waveform changes. If the values shown in FIGURE 5 are used, the top and bottom of an unmodulated or "flat field" raster will display banded regions of differing intensity, actually row to row differences in vertical placement of horizontal scan lines. The result of such correction waveform discontinuities is shown in FIGURE 6, which for illustrative purposes is exaggerated and ignores optical projection brightness effects. The banded regions, depicted in FIGURE 6, result from abrupt changes in slope near the ends of some of the plots. Since the green CRT (image) contributes about 60% of the luminance of a white field, such brightness banding is most noticeable and unacceptable.

If the correction values along each column had no changes of slope, as shown in FIGURE 7, banding is eliminated. Banding can be minimized or eliminated by altering the correction factors used, to smooth the changes in slope. For example, the data can be adjusted such that the second derivative of the correction waveform along each column is, continuous, or nearly continuous. Banding could be wholly eliminated by making the correction waveforms along each column linear, for example, making the second derivative zero.

Banding may be eliminated by taking measured correction values for horizontal matrix or adjustment lines 2 and 12 of each column, and calculating a straight line between these values, that is, linearly interpolating the entire waveform for each column. However, such a linear column correction results in imperfect correction of vertical pincushion distortion because the required geometrically-dictated correction waveform is S-shaped, rather than a linear function, and has an amplitude that varies with the position of the column relative to the center vertical axis of the screen. This linearized, rather than S-shaped correction waveform produces a crosshatch display with straight top and bottom horizontal lines (2 & 12) and pincushion curvature inward from the top and bottom reducing to zero distortion at centerline (7) on all the inside horizontal lines. The resultant geometric distortion is depicted in FIGURE 8. Horizontal matrix lines 1 and 13 are not visible because they are occur

beyond the displayed area but if they were visible, they would slightly barrel outward. Pincushion curvature of this type is unacceptable because it geometrically distorts the image as a function of position on the screen. For example, the distortion causes curved edges of on-screen picture elements that a viewer knows to be straight. Blocks and lines such as the edges of menus and stock market strips, for example, are expected and required to appear straight.

A vertical rate analog convergence signal with an S-shape may be employed to correct the inner pincushion distortion described above, and to make fine adjustments to address the remaining distortion with signals derived from digital correction factors. Since the analog correction is continuous and a digital part of the correction may be relatively small, problems with banding and pincushion distortion are reduced. However, consistency of such analog correction signal is difficult to maintain due to component tolerance and temperature variations. Thus resulting compensation for such analog signal instability may result in undesirable added circuit complexity, cost and power dissipation.

It is possible to calculate and store correction values of each raster line. This calculation can include forcing a continuous or zero second derivative along each correction column. However, this method is relatively costly and complex, and may suffer from the tradeoff between banding minimization and pincushion distortion, as discussed above.

In a display, banding may be minimized to be substantially unnoticeable in the interest of accurate displayed image geometry. It was found experimentally in equipment according to this example, that banding in a flat field video image was substantially undetectable if the slope changes in the linearly interpolated data were permitted but held to be within a minimized range. For example, the curve for a vertical column may be adjusted to bend no more than plus or minus five steps of a Digital to Analog Converter (DAC) per crosshatch adjustment segment. A maximum curvature of three steps per adjustment segment was selected to facilitate S correction while

maintaining banding at a substantially undetectable level.

According to an inventive aspect, a modified linearization technique is used to concurrently render banding substantially undetectable and significantly reduce distortion resulting from correction value linearization. Referring to the matrix of FIGURE 3, for example, a vertical sawtooth waveform is generated by bus controlled waveform generator 21 and coupled to drive the three vertical deflection yokes GV, RV, BV. The vertical saw is adjusted within generator 21 to provide S-correction to minimize the geometric distortion of the crosshatch along columns F and N. These columns then have linear convergence correction in the vertical direction. Thus S-correction in the vertical deflection coil minimizes the magnitude of S-curvature correction signal applied to the convergence coil, which changes polarity on opposite sides of the axial center. The other columns are given correction coil S correction which is limited to 3 LSB steps divergence from the linear value. Columns A-D, H-L and P have 3 step curvature and columns E, G, M and O have 2 step curvature. The result is a simultaneous minimization of banding and pincushion distortion, such that a significantly improved picture can be consistently achieved with digital convergence correction using linear interpolation between successive correction matrix points.

Column curves obtained from the equations are shown in FIGURE 9 and the equations are set forth in FIGURE 10. The resulting crosshatch display produced with these equations is substantially as the ideal cross hatch shown in FIGURE 3.

Devices that provide digital convergence correction with linear interpolation can be corrected for banding by forcing the second derivative of the correction waveform to be continuous at the endpoints of adjacent interpolation intervals. The invention described herein maintains the second derivative at substantially zero by linearization in the necessary areas, thereby removing banding. This is performed using linear interpolation with adjustments according to the equations shown.

According to an inventive aspect, specific horizontal lines located along the correction node points of a generated video

crosshatch pattern are measured and corrected. According to a further aspect, only the green vertical corrections preferably are subject to banding linearization algorithm to render banding in the green display image imperceptible. The green vertical raster component is corrected because the green image contributes about 60% of the perceived display brightness and thus visible image degradation results if banding is present. Since the red and blue images contribute smaller amounts to the overall brightness, about 30% and 10 % respectively, their contributions to the visibility of banding may be ignored. Red and blue raster corrections may be calculated to place them exactly on top of the green image without the requirement for linearization to suppress banding. However, use of the banding linearization algorithm is not excluded from use for red and blue raster corrections.

Since the vertical corrections are somewhat interactive, the entire alignment process is iterative with measurements of line location being made and corrections calculated and applied until lines 2, 7 and 12 (of FIGURE 3) are in the geometrically correct, absolute locations. Inasmuch as the slope or first derivative of the correction waveform down a column is constant where linearized, the second derivative is zero. The mathematical requirements are satisfied, and banding is eliminated.

In a simplified example matrix shown in FIGURE 11A, measurements are made to determine the exact location for only lines 1 and 5. The locations of the intervening lines 2 - 4 are determined by calculating the difference between the values of correction 1 and correction 5 and dividing by the number of intervening nodes minus 1. This correction differential is added to the preceding value to establish the correction value at node N-1, and represents the correction increment down each column between lines L1 and L5.

One artifact of this approach is that the intervening node points may not be at desired locations. In fact, the locations of these lines tend to result in inner pincushion distortion. In FIGURE 11A lines 2 and 4 would exhibit some degree of curvature, which might be objectionable. The amount of distortion is dependent on optics and

projected image magnification. Although banding may be eliminated by reducing the second derivative to zero by linearization, it was recognized that banding may be rendered substantially undetectable even if the second derivative is not zero but allowed to have a small, limited variation. In an inventive arrangement geometric distortion, for example inner pincushion, may be corrected by the addition of an S-component to specific columns of corrections. The small variation or difference between correction values which provides S-correction depends on various system considerations, for example, the number of vertical measurement nodes, the number of D/A steps utilized, the deflection sensitivity and the like. In this exemplary system the variation corresponds to about two to three least significant bits (LSB's) in the corrections written to the nodes. This allowable variation permits a small degree of S-correction to be added certain columns of correction values. Due to symmetry about the center, the magnitude of the required S-correction increases as the area of interest moves away from center and then decreases approaching the edge.

FIGURE 12 is a simplified flow chart depicting a method for the derivation and application of the corrective values of FIGURE 10, which render banding undetectable and provide S-correction to a vertical raster component. FIGURE 11B illustrates inner pincushion distortion. FIGURE 11A simplified matrix which demonstrates the effect of adding S-correction, in an example that assumes that the columns have only five matrix points representing the top, bottom, midpoint and two quarter points. In this example, if the correction range is 0 to 1023, which allows correction variation on the order of 6 to 12 correction steps. Assuming for the five vertical matrix points of column 1 that nodes C_1 and C_5 have measured correction values of 100 and 500 respectively, absolute banding removal by linearization would provide values of:

C_1=100
C_2=200
C_3=300
C_4=400
C_5=500

If maximum S-correction is 12 correction steps, the result is:

C_1=100
C_2=212
C_3=300
C_4=388
C_5=500

The added S-correction has the effect of moving location C_2 downward while moving location C_4 upward. In this simplified model, the second column Col2, uses half of the correction of column Col1 with the center column, Col3, requiring no S-correction.

A further refinement is useful in production situations where the variability of optics and electronics assemblies requires additional adjustment. As applied to the above example, this refinement consists of optimization of the magnitude of S correction, within the 2-3 LSB limitations, to achieve the best positioning (pincushion minimization) of lines 2 and 4 down each of the columns. This approach, although empirical and iterative in nature, becomes much more effective as the number of nodes down a column increases.

Application of the methods disclosed above renders banding artifacts, common to digital convergence correction devices, substantially undetectable while minimizing geometric image distortion.

CLAIMS

5. A video display apparatus, comprising:

a cathode ray tube (10) for displaying an image, having a deflection correction coil (GVC) mounted thereon and coupled to drive amplifier (107);

a digital to analog converter (105) with an output coupled to said drive amplifier (107);

a memory (104) containing displacement values applicable to spaced points in a grid of rows (1-13) and columns (A-P), said displacement values for said columns (A-P) generally defining S-shaped correction curves having a maximum value at two areas of a display screen located substantially between a center axis (7) and ones of top and bottom edges (2,13) of the display, said S-shaped correction curves having substantially zero value at areas adjacent to said center axis (7) and said edges (2,13); and,

interpolating means (102) for interpolating intervening values adjacent ones of said displacement values and having an output coupled to said digital to analog converter (105) for generating a corrective signal (I2corG) to drive said deflection correction coil (GVC) for locally adjusting a position of said image such that banding and pincushion distortion are controlled.

6. The video display of claim 5, wherein S-shaped correction is added in successive steps proceeding from said areas located substantially between said center axis (7) and said ones of top and bottom edges (2,13), toward said center axis (7) and toward said edges (2,13), respectively.

7. The video display of claim 5, wherein said digital words stored in said memory (104) represent values derived during alignment of said video display.

8. The video display of claim 5, wherein said digital words defining displacement values stored in said memory represent values formed by interpolation of displacement values applicable to said grid.

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10. The video display of claim 5, wherein said linear interpolating means generates said intervening values adjacent ones of said displacement values during a display period.

12. A method for digitally correcting geometric distortion of an image on a display screen, comprising the steps of:

defining a matrix of spaced adjustment points (A1-P13) on the display screen, in horizontally spaced vertical columns (A-P) of values for local displacement of the image at the adjustment points on the display screen, the values for said columns defining S-shaped vertical correction waveforms having varying slope between adjacent ones of the values;

linearizing the values for at least two areas of the matrix corresponding to a center axis (7) and top and bottom edges (2,13), and applying progressively greater S-correction proceeding from said center axis and from said edges, to areas of the display screen located substantially between said center axis (7) and said edges (2,13);

storing the matrix values in a memory (104);

reading said stored matrix values; and,

locally displacing said image as a function of said stored matrix values for corresponding adjustment points to correct the image on the display screen such that banding and pincushion distortion are controlled.

13. The method of claim 12, further comprising linearly interpolating between adjacent ones of the matrix values in said vertical columns (A-P) to define correction values for scan lines between the adjustment points, and locally displacing the image between the adjustment points as a function of the linearly interpolated correction values.

ABSTRACT

A projection display uses a matrix of digital correction factors defining deflection correction factors between which linear interpolation is used for intermediate points on the display. A circuit for generating a correction signal to correct image distortion on a display screen, comprises a memory storing displacement values corresponding to spaced points on the screen in a grid of rows and columns. The displacement values of the grid generally define correction curves for correcting the image distortion without introducing significant banded regions on the display screen. An interpolator is coupled to the memory for interpolating intermediate values between adjacent ones of the stored displacement values, and a digital to analog converter is coupled to the interpolator for providing the correction signal.

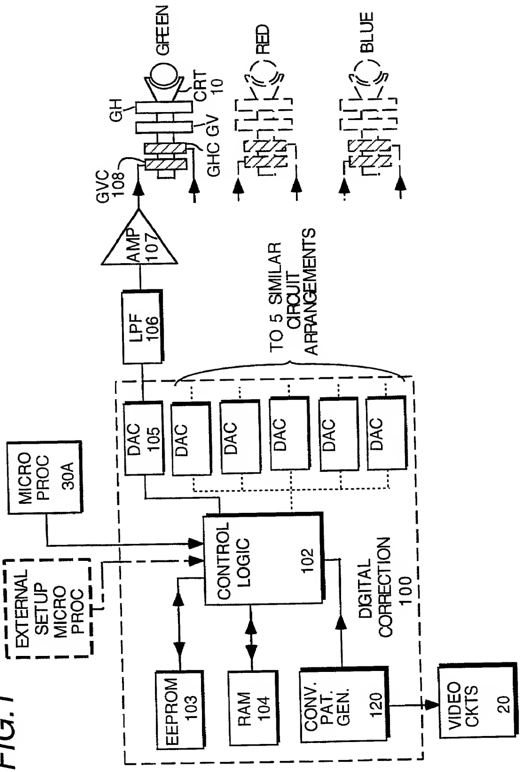

GREEN
RED
BLUE
CRT 10
GH
GV
GHC
GVC 108
AMP 107
LPF 106
TO 5 SIMILAR CIRCUIT ARRANGEMENTS
DAC 105
DAC
DAC
DAC
DAC
DAC
MICRO PROC 30A
EXTERNAL SETUP MICRO PROC
CONTROL LOGIC 102
DIGITAL CORRECTION 100
EEPROM 103
RAM 104
CONV. PAT. GEN. 120
VIDEO CKTS 20

FIG.1

FIG. 2

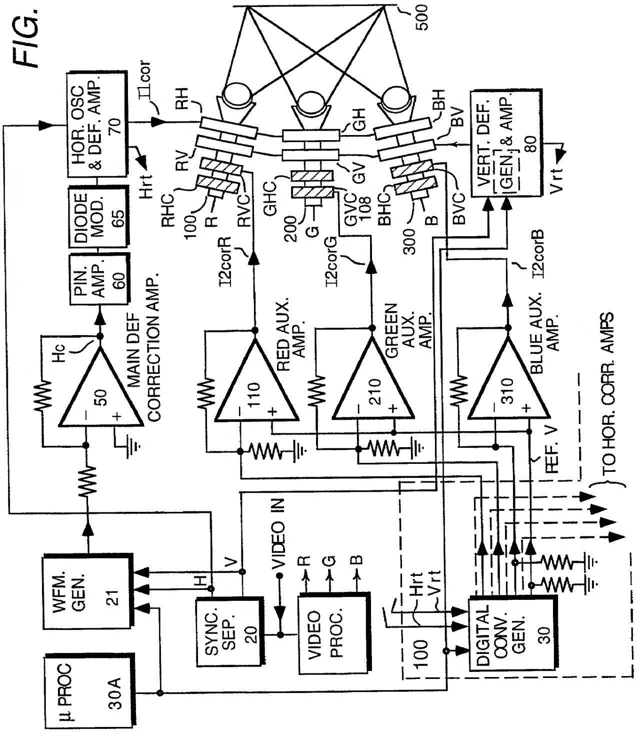

HOR. OSC & DEF. AMP. 70
I1cor
Hrt
DIODE MOD. 65
PIN. AMP. 60
MAIN DEF CORRECTION AMP.
Hc
50
RH
RV
RHC
100
R
RVC
GH
GV
GHC
200
G
GVC 108
BH
BV
BHC
300
B
BVC
500
VERT. DEF. [GEN.] & AMP. 80
Vrt
I2corR
I2corG
I2corB
RED AUX. AMP.
110
GREEN AUX. AMP.
210
BLUE AUX. AMP.
310
REF. V
TO HOR. CORR. AMPS
WFM. GEN. 21
H
V
SYNC. SEP. 20
VIDEO IN
VIDEO PROC.
R
G
B
Hrt
Vrt
DIGITAL CONV. GEN. 30
100
µ PROC 30A

FIG.3

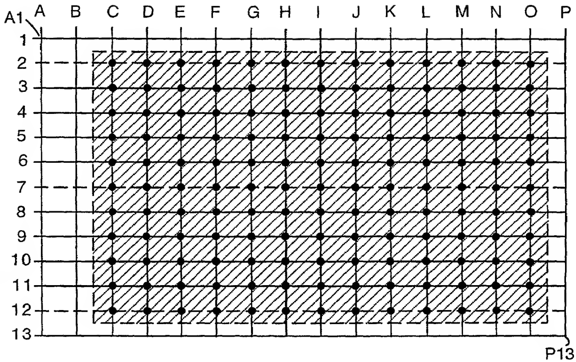

A1
A B C D E F G H I J K L M N O P
1
2
3
4
5
6
7
8
9
10
11
12
13
P13

FIG.4

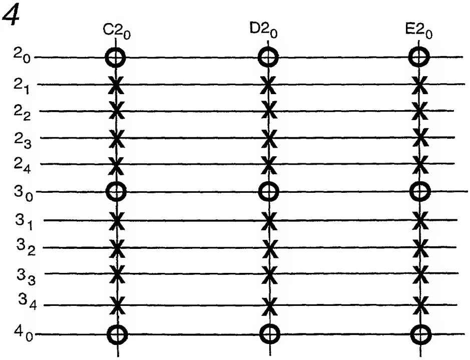

$C2_0$ $D2_0$ $E2_0$
2_0
2_1
2_2
2_3
2_4
3_0
3_1
3_2
3_3
3_4
4_0

FIG. 5

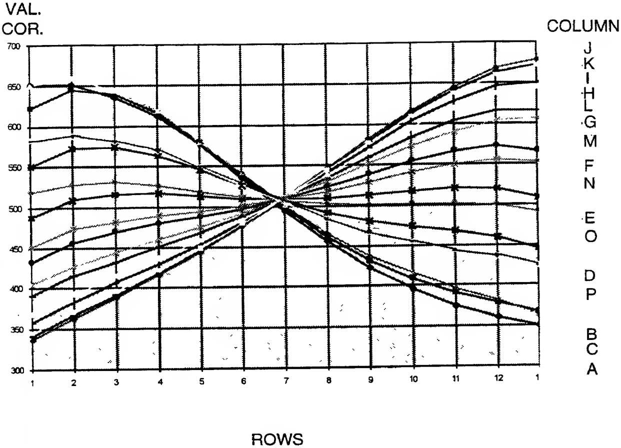

VAL.
COR.
700
650
600
550
500
450
400
350
300
1
2
3
4
5
6
7
8
9
10
11
12
1
COLUMN
J
K
I
H
L
G
M
F
N
E
O
D
P
B
C
A
ROWS

FIG. 6

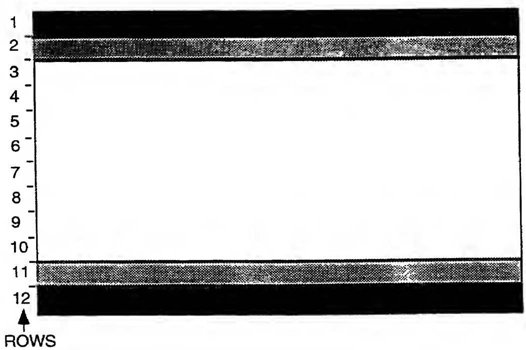

1
2
3
4
5
6
7
8
9
10
11
12
ROWS

FIG. 7

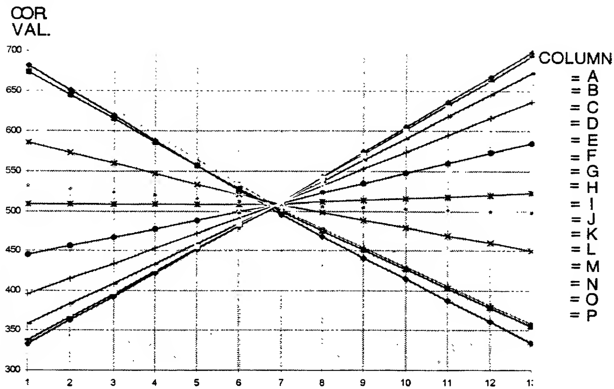

COR
VAL.
700
650
600
550
500
450
400
350
300
1
2
3
4
5
6
7
8
9
10
11
12
COLUMN
= A
= B
= C
= D
= E
= F
= G
= H
= I
= J
= K
= L
= M
= N
= O
= P

FIG. 8

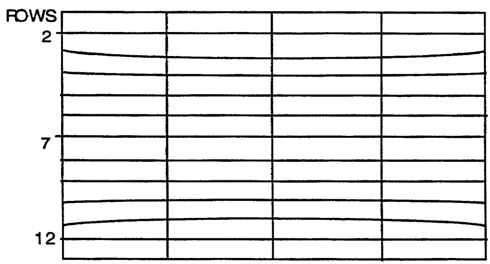

ROWS
2
7
12

FIG.9

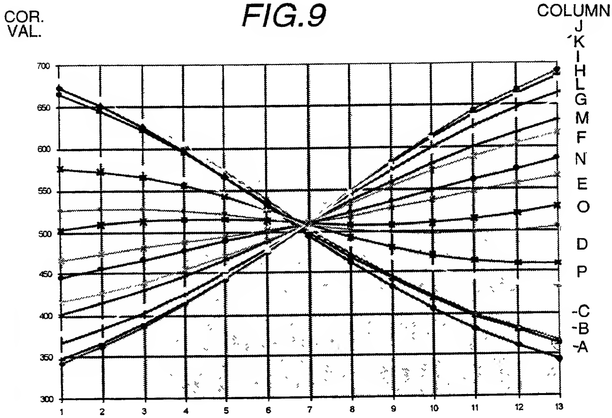


FIG. 11A

GIVEN

$C_1 = 100$

$C_5 = 500$

Nodes N = 5

Then Slope (d/dt)

$$= \frac{C_5 - C_1}{N-1}$$

$$= \frac{500 - 100}{4} = 100$$

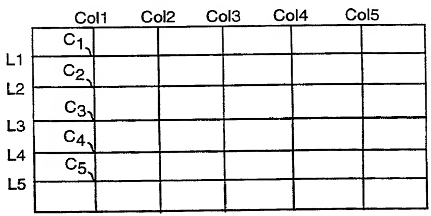


FIG. 11B

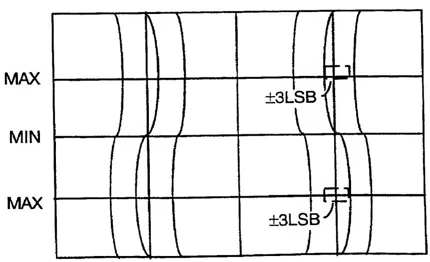


FIG. 10

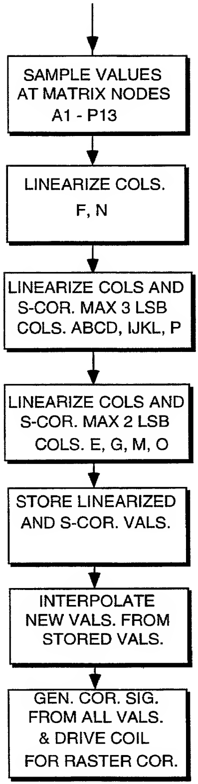
COLUMNS

1 (A)	2 (B)	3 (C)	4 (D)	5 (E)	6 (F)	7 (G)	8 (H)
A7+1.2*(A2-A7)-9	B7+1.2*(B2-B7)-9	C7+1.2*(C2-C7)-9	D7+1.2*(D2-D7)-9	E7+1.2*(E2-E7)-6	F7+1.2*(F2-F7)	G7+1.2*(G2-G7)+6	H7+1.2*(H2-H7)+9
A2	B2	C2	D2	E2	F2	G2	H2
A7+0.8*(A2-A7)+6	B7+0.8*(B2-B7)+6	C7+0.8*(C2-C7)+6	D7+0.8*(D2-D7)+6	E7+0.8*(E2-E7)+4	F7+0.8*(F2-F7)	G7+0.8*(G2-G7)-4	H7+0.8*(H2-H7)-6
A7+0.6*(A2-A7)+9	B7+0.6*(B2-B7)+9	C7+0.6*(C2-C7)+9	D7+0.6*(D2-D7)+9	E7+0.6*(E2-E7)+6	F7+0.6*(F2-F7)	G7+0.6*(G2-G7)-6	H7+0.6*(H2-H7)-9
A7+0.4*(A2-A7)+9	B7+0.4*(B2-B7)+9	C7+0.4*(C2-C7)+9	D7+0.4*(D2-D7)+9	E7+0.4*(E2-E7)+6	F7+0.4*(F2-F7)	G7+0.4*(G2-G7)-6	H7+0.4*(H2-H7)-9
A7+0.2*(A2-A7)+6	B7+0.2*(B2-B7)+6	C7+0.2*(C2-C7)+6	D7+0.2*(D2-D7)+6	E7+0.2*(E2-E7)+4	F7+0.2*(F2-F7)	G7+0.2*(G2-G7)-4	H7+0.2*(H2-H7)-6
A7	B7	C7	D7	E7	F7	G7	H7
A7+0.2*(A12-A7)-6	B7+0.2*(B12-B7)-6	C7+0.2*(C12-C7)-6	D7+0.2*(D12-D7)-6	E7+0.2*(E12-E7)-4	F7+0.2*(F12-F7)	G7+0.2*(G12-G7)+4	H7+0.2*(H12-H7)+6
A7+0.4*(A12-A7)-9	B7+0.4*(B12-B7)-9	C7+0.4*(C12-C7)-9	D7+0.4*(D12-D7)-9	E7+0.4*(E12-E7)-6	F7+0.4*(F12-F7)	G7+0.4*(G12-G7)+6	H7+0.4*(H12-H7)+9
A7+0.6*(A12-A7)-9	B7+0.6*(B12-B7)-9	C7+0.6*(C12-C7)-9	D7+0.6*(D12-D7)-9	E7+0.6*(E12-E7)-6	F7+0.6*(F12-F7)	G7+0.6*(G12-G7)+6	H7+0.6*(H12-H7)+9
A7+0.8*(A12-A7)-6	B7+0.8*(B12-B7)-6	C7+0.8*(C12-C7)-6	D7+0.8*(D12-D7)-6	E7+0.8*(E12-E7)-4	F7+0.8*(F12-F7)	G7+0.8*(G12-G7)+4	H7+0.8*(H12-H7)+6
A12	B12	C12	D12	E12	F12	G12	H12
A7+1.2*(A12-A7)+9	B7+1.2*(B12-B7)+9	C7+1.2*(C12-C7)+9	D7+1.2*(D12-D7)+9	E7+1.2*(E12-E7)+6	F7+1.2*(F12-F7)	G7+1.2*(G12-G7)-6	H7+1.2*(H12-H7)-9

COLUMNS

9 (I)	10 (J)	11 (K)	12 (L)	13 (M)	14 (N)	15 (O)	16 (P)
I7+1.2*(I2-I7)+9	J7+1.2*(J2-J7)+9	K7+1.2*(K2-K7)+9	L7+1.2*(L2-L7)+9	M7+1.2*(M2-M7)+6	N7+1.2*(N2-N7)	O7+1.2*(O2-O7)-6	P7+1.2*(P2-P7)-9
I2	J2	K2	L2	M2	N2	O2	P2
I7+0.8*(I2-I7)-6	J7+0.8*(J2-J7)-6	K7+0.8*(K2-K7)-6	L7+0.8*(L2-L7)-6	M7+0.8*(M2-M7)-4	N7+0.8*(N2-N7)	O7+0.8*(O2-O7)+4	P7+0.8*(P2-P7)+6
I7+0.6*(I2-I7)-9	J7+0.6*(J2-J7)-9	K7+0.6*(K2-K7)-9	L7+0.6*(L2-L7)-9	M7+0.6*(M2-M7)-6	N7+0.6*(N2-N7)	O7+0.6*(O2-O7)+6	P7+0.6*(P2-P7)+9
I7+0.4*(I2-I7)-9	J7+0.4*(J2-J7)-9	K7+0.4*(K2-K7)-9	L7+0.4*(L2-L7)-9	M7+0.4*(M2-M7)-6	N7+0.4*(N2-N7)	O7+0.4*(O2-O7)+6	P7+0.4*(P2-P7)+9
I7+0.2*(I2-I7)-6	J7+0.2*(J2-J7)-6	K7+0.2*(K2-K7)-6	L7+0.2*(L2-L7)-6	M7+0.2*(M2-M7)-4	N7+0.2*(N2-N7)	O7+0.2*(O2-O7)+4	P7+0.2*(P2-P7)+6
I7	J7	K7	L7	M7	N7	O7	P7
I7+0.2*(I12-I7)+6	J7+0.2*(J12-J7)+6	K7+0.2*(K12-K7)+6	L7+0.2*(L12-L7)+6	M7+0.2*(M12-M7)+4	N7+0.2*(N12-N7)	O7+0.2*(O12-O7)-4	P7+0.2*(P12-P7)-6
I7+0.4*(I12-I7)+9	J7+0.4*(J12-J7)+9	K7+0.4*(K12-K7)+9	L7+0.4*(L12-L7)+9	M7+0.4*(M12-M7)+6	N7+0.4*(N12-N7)	O7+0.4*(O12-O7)-6	P7+0.4*(P12-P7)-9
I7+0.6*(I12-I7)+9	J7+0.6*(J12-J7)+9	K7+0.6*(K12-K7)+9	L7+0.6*(L12-L7)+9	M7+0.6*(M12-M7)+6	N7+0.6*(N12-N7)	O7+0.6*(O12-O7)-6	P7+0.6*(P12-P7)-9
I7+0.8*(I12-I7)+6	J7+0.8*(J12-J7)+6	K7+0.8*(K12-K7)+6	L7+0.8*(L12-L7)+6	M7+0.8*(M12-M7)+4	N7+0.8*(N12-N7)	O7+0.8*(O12-O7)-4	P7+0.8*(P12-P7)-6
I12	J12	K12	L12	M12	N12	O12	P12
I7+1.2*(I12-I7)-9	J7+1.2*(J12-J7)-9	K7+1.2*(K12-K7)-9	L7+1.2*(L12-L7)-9	M7+1.2*(M12-M7)-6	N7+1.2*(N12-N7)	O7+1.2*(O12-O7)+6	P7+1.2*(P12-P7)+9

FIG. 12


SAMPLE VALUES AT MATRIX NODES A1 - P13
LINEARIZE COLS. F, N
LINEARIZE COLS AND S-COR. MAX 3 LSB COLS. ABCD, IJKL, P
LINEARIZE COLS AND S-COR. MAX 2 LSB COLS. E, G, M, O
STORE LINEARIZED AND S-COR. VALS.
INTERPOLATE NEW VALS. FROM STORED VALS.
GEN. COR. SIG. FROM ALL VALS. & DRIVE COIL FOR RASTER COR.

COMBINED DECLARATION FOR PATENT APPLICATION AND POWER OF ATTORNEY
(Includes Reference to PCT International Applications)

ATTORNEY'S DOCKET NUMBER: 88741

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name,

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

DIGITAL RASTER CORRECTION

the specification of which (check only one item below):

☐ is attached hereto.

☐ was filed as United States application

Serial No. ______________________

on ______________________,

and was amended

on ______________________ (if applicable).

☒ was filed as PCT international application

Number PCT/US98/17920

on 28 August 1998,

and was amended under PCT Article ~~19~~ 34

on 16 September 1999 (if applicable).

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowlege the duty to disclose information which is material to the examination of this application in accordance with Title 37, Code of Federal Regulations, §1.56(a).

I hereby claim foreign priority benefits under Title 35, United States Code, §119 of any foreign application(s) for patent or inventor's certificate or of any PCT international application(s) designating at least one country other than the United States of America listed below and have also identified below any foreign application(s) for patent or inventor's certificate or any PCT international application(s) designating at least one country other than the United States of America filed by me on the same subject matter having a filing date before that of the application(s) of which priority is claimed:

PRIOR FOREIGN/PCT APPLICATION(S) AND ANY PRIORITY CLAIMS UNDER 35 U.S.C. 119:

COUNTRY (if PCT, indicate 'PCT')	APPLICATION NUMBER	DATE OF FILING (day, month, year)	PRIORITY CLAIMED UNDER 35 USC 119
			☐ YES ☐ NO
			☐ YES ☐ NO
			☐ YES ☐ NO
			☐ YES ☐ NO
			☐ YES ☐ NO

09/485940

Combined Declaration For Patent Application and Power of Attorney (Continued)
(Includes Reference to PCT International Applications)

ATTORNEY'S DOCKET NUMBER RCA 88741

416 Rec'd PCT/PTO 18 FEB 2000

I hereby claim the benefit under Title 35, United States Code, §120 of any United States application(s) or PCT international application(s) designating the United States of America that is/are listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in that/those prior application(s) in the manner provided by the first paragraph of Title 35, United States Code, §112, I acknowlege the duty to disclose material information as defined in Title 37, Code of Federal Regulations, §1.56(a) which occurred between the filing date of the prior application(s) and the national or PCT international filing date of this application:

PRIOR U.S. APPLICATIONS OR PCT INTERNATIONAL APPLICATIONS DESIGNATING THE U.S. FOR BENEFIT UNDER 35 U.S.C. 120:

U S APPLICATIONS			STATUS (Check one)		
U S APPLICATION NUMBER	U S FILING DATE		PATENTED	PENDING	ABANDONED
60/057,250	29 August 1997				
PCT APPLICATIONS DESIGNATING THE U S.					
PCT APPLICATION NO	PCT FILING DATE	U S SERIAL NUMBERS ASSIGNED (if any)			
PCT/US98/17920	28August1998(28.08.98)				

POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith. *(List name and registration number)*

Joseph S. Tripoli - Reg. No. 26,040
Joseph J. Laks - Reg. No. 27,914
Francis A. Davenport - Reg. No. 36,316

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Mr. Joseph S. Tripoli - Patent Operations
THOMSON multimedia Licensing Inc.
PO Box 5312
Princeton, New Jersey 08540 US

Direct Telephone Calls to: *(name and telephone number)*
1-609-734-9864

201	FULL NAME OF INVENTOR	FAMILY NAME: GEORGE	FIRST GIVEN NAME: John	SECOND GIVEN NAME: Barrett
	RESIDENCE & CITIZENSHIP	CITY: Carmel	STATE OR FOREIGN COUNTRY: Indiana	COUNTRY OF CITIZENSHIP: US
	POST OFFICE ADDRESS	POST OFFICE ADDRESS: 11408 Lakeshore Drive East	CITY: Carmel	STATE & ZIP CODE/COUNTRY: Indiana 46033 US
202	FULL NAME OF INVENTOR	FAMILY NAME: GLAD	FIRST GIVEN NAME: Frank	SECOND GIVEN NAME: Albert
	RESIDENCE & CITIZENSHIP	CITY: El Paso	STATE OR FOREIGN COUNTRY: Texas	COUNTRY OF CITIZENSHIP: US
	POST OFFICE ADDRESS	POST OFFICE ADDRESS: 1123 Eagle Ridge Drive	CITY: El Paso	STATE & ZIP CODE/COUNTRY: Texas 79912 US
203	FULL NAME OF INVENTOR	FAMILY NAME	FIRST GIVEN NAME	SECOND GIVEN NAME
	RESIDENCE & CITIZENSHIP	CITY	STATE OR FOREIGN COUNTRY	COUNTRY OF CITIZENSHIP
	POST OFFICE ADDRESS	POST OFFICE ADDRESS	CITY	STATE & ZIP CODE/COUNTRY

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

SIGNATURE OF INVENTOR 201	SIGNATURE OF INVENTOR 202	SIGNATURE OF INVENTOR 203
John Barrett George	Frank Albert Glad Frank Albert Glad	
DATE 2000	DATE 2/14/2000 2000	DATE

EXPRESS MAIL EL530649428US

COMBINED DECLARATION FOR PATENT APPLICATION AND POWER OF ATTORNEY

(Includes Reference to PCT International Applications)

ATTORNEY S DOCKET NUMBER
88741

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name,

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

DIGITAL RASTER CORRECTION

the specification of which (check only one item below):

☐ is attached hereto.

☐ was filed as United States application

Serial No. ____________

on ____________,

and was amended

on ____________ (if applicable).

☒ was filed as PCT international application

Number PCT/US98/17920

on 28 August 1998,

and was amended under PCT Article ~~19~~ 34

on 16 September 1999 (if applicable).

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowlege the duty to disclose information which is material to the examination of this application in accordance with Title 37, Code of Federal Regulations, §1.56(a).

I hereby claim foreign priority benefits under Title 35, United States Code, §119 of any foreign application(s) for patent or inventor's certificate or of any PCT international application(s) designating at least one country other than the United States of America listed below and have also identified below any foreign application(s) for patent or inventor's certificate or any PCT international application(s) designating at least one country other than the United States of America filed by me on the same subject matter having a filing date before that of the application(s) of which priority is claimed:

PRIOR FOREIGN/PCT APPLICATION(S) AND ANY PRIORITY CLAIMS UNDER 35 U.S.C. 119:

COUNTRY (if PCT, indicate "PCT")	APPLICATION NUMBER	DATE OF FILING (day, month, year)	PRIORITY CLAIMED UNDER 35 USC 119
			☐ YES ☐ NO
			☐ YES ☐ NO
			☐ YES ☐ NO
			☐ YES ☐ NO
			☐ YES ☐ NO

Combined Declaration For Patent Application and Power of Attorney (Continued)

(Includes Reference to PCT International Applications)

ATTORNEY DOCKET NUMBER
RCA 88741

I hereby claim the benefit under Title 35, United States Code, §120 of any United States application(s) or PCT international application(s) designating the United States of America that is/are listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in that/those prior application(s) in the manner provided by the first paragraph of Title 35, United States Code, §112, I acknowlege the duty to disclose material information as defined in Title 37, Code of Federal Regulations, §1.56(a) which occurred between the filing date of the prior application(s) and the national or PCT international filing date of this application:

PRIOR U.S. APPLICATIONS OR PCT INTERNATIONAL APPLICATIONS DESIGNATING THE U.S. FOR BENEFIT UNDER 35 U.S.C. 120:

U.S. APPLICATIONS		STATUS *(Check one)*		
U.S. APPLICATION NUMBER	U.S. FILING DATE	PATENTED	PENDING	ABANDONED
60/057,250	29 August 1997			

PCT APPLICATIONS DESIGNATING THE U.S.

PCT APPLICATION NO	PCT FILING DATE	U.S. SERIAL NUMBERS ASSIGNED *(if any)*	PATENTED	PENDING	ABANDONED
PCT/US98/17920	28August1998(28.08.98)				

POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith. ***(List name and registration number)***

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	POST OFFICE ADDRESS	POST OFFICE ADDRESS	CITY	STATE & ZIP CODE/COUNTRY

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

SIGNATURE OF INVENTOR 201	SIGNATURE OF INVENTOR 202	SIGNATURE OF INVENTOR 203
John Barrett George John Barrett George	Frank Albert Glad	
DATE: February 9, 2000	DATE: 2000	DATE